



United States General Accounting Office

Report to the Chairman and Ranking

Minority Member, Committee on

Science, House of Representatives

May 1995

WEATHER

FORECASTING

Radar Availability

Requirement Not Being  
Met



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United States  
General Accounting Office  
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Accounting and Information  
Management Division

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May 31, 1995

The Honorable Robert S. Walker  
Chairman  
The Honorable George E. Brown, Jr.  
Ranking Minority Member  
Committee on Science  
House of Representatives

This report responds to your request that we review the Next Generation Weather Radar (NEXRAD), a Doppler weather radar that the Departments of Commerce, Defense, and Transportation are jointly acquiring. As agreed, we focused on changes in the number of NEXRADs being deployed, contract options to purchase additional radar units, the Air Force's contribution to the national NEXRAD network, and the accessibility and availability of NEXRADs.

We are providing copies of this report to the Secretaries of Commerce, Defense, Transportation, and the Air Force; the Director of the Office of Management and Budget; and other interested congressional committees. Copies will also be made available to others upon request.

Please call me at (202) 512-6253 if you or your staff have any questions concerning this report. Major contributors are listed in appendix III.

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Director, Information Resources  
Management/Resources, Community,  
and Economic Development

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# Executive Summary

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## Purpose

One needs to look no further than the evening news to appreciate how Doppler radar systems<sup>1</sup> are allowing forecasters to better see the makeup and movement of weather and to quickly advise the public of severe events, such as tornadoes. As part of its approximately \$4.5 billion systems modernization program, the National Weather Service (NWS), a component of the National Oceanic and Atmospheric Administration (NOAA), is collaborating with the Federal Aviation Administration (FAA) and the Air Force in acquiring Doppler radar technology. This \$1.4 billion radar project, known as the Next Generation Weather Radar (NEXRAD), is to establish a constellation of radars to increase the accuracy, timeliness, and credibility of hazardous weather warnings.

Recent changes to the deployment schedule, uncertainties about the need for additional radars, and questions concerning interagency cooperation prompted the Chairman and Ranking Minority Member of the House Committee on Science to request that GAO determine (1) the NEXRAD units that were dropped from the original deployment plan and the reasons they were dropped, (2) the feasibility and estimated cost of extending the NEXRAD contract to purchase additional radars, (3) the Air Force NEXRADs' contribution to the national NEXRAD network and the accessibility of the Air Force NEXRAD data to civilian forecasters, and (4) the availability of the Air Force and NWS NEXRADs. Our objectives did not include determining the adequacy of national radar coverage because the National Research Council (NRC) is reporting separately on this issue.

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## Background

NEXRAD is a Doppler radar system that measures wind velocity in severe weather, tracks storm movement and intensity, and generates data and imagery for forecasters and other users. NWS and the Air Force report that their experience with the data from over 100 operational NEXRADs has increased the accuracy, timeliness, and credibility of warnings of severe thunderstorms, tornadoes, flash floods, turbulence, wind shear, and other types of hazardous weather events.

NWS, the Air Force, and FAA currently plan to purchase and deploy 119, 30, and 14 NEXRADs, respectively, for a total of 163. As of February 1995, 107 radars had been deployed—81 by NWS, 22 by the Air Force, and 4 by FAA. Of the 163 planned radars, 144 are to be located at NWS and Defense

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<sup>1</sup>Doppler radar is used to determine the speed and direction of rain or snow particles, cloud droplets, or dust moving toward or away from the radar. The radar accomplishes this by sending out a pulse using a stable frequency and then measuring the changing frequencies as the distance between the radar and the object changes.

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sites within the conterminous United States (CONUS).<sup>2</sup> These CONUS sites are to provide adequate geographic coverage of national weather events, thereby collectively supporting the three agencies' respective missions. The non-CONUS radars are also to support the agencies' respective missions at 19 selected locations in Hawaii, Alaska, the Caribbean, the Atlantic, the Pacific, and Korea. NWS relies on several of these 19 non-CONUS radars to provide information about approaching off-shore weather. FAA and the Air Force rely on many of these 19 radars to ensure safe aviation operations and resource protection.

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## Results in Brief

Originally the three agencies planned to deploy 175 radars.<sup>3</sup> Recent changes to the NEXRAD deployment plan have decreased the number to 163. These changes are because of changes to agency requirements, military base closings, and funding limitations. Also, FAA and NWS officials told GAO that FAA will delay deploying five of its radars for probably more than a year because of budget constraints.

A NEXRAD contract option exists to acquire up to 20 additional radars. These radars could be as much as three times as expensive as current units because manufacturer production lines have been shut down, and restarting them would involve considerable expense. NWS officials told GAO that the 163 radars will provide coverage equal to or better than the existing coverage. The 163 radars are expected to meet the needs of the three agencies, and the agencies do not plan to acquire additional NEXRADs. Therefore, NWS has not reassessed the cost-effectiveness of acquiring additional radars under the contract option. However, the NRC study director stated that NRC expects to report on weaknesses in national coverage that may require NWS to buy additional radars, assuming that the benefits of doing so outweigh the associated cost.

According to NWS, the Air Force NEXRADs are essential to NWS' ability to issue quality forecasts and warnings because some provide the sole radar coverage for certain geographic areas, and all provide backup coverage in the event an NWS radar goes down. The Air Force does not restrict NWS forecasters' access to its radar data; however, Air Force data show that its radars are not available<sup>4</sup> to the extent that the three agencies agreed is necessary. To make matters worse, the Air Force availability data are

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<sup>2</sup>The conterminous United States consists of all the states except Alaska and Hawaii.

<sup>3</sup>These 175 radars included 115 for NWS, 44 for the Air Force, and 16 for FAA.

<sup>4</sup>Available means the time that the system is operating satisfactorily, expressed as a percentage of total time.

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unreliable and appear to be overstated. Also, NWS does not know if its individual radars are available to the extent necessary because it does not monitor radar availability by site.

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## Principal Findings

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### Global NEXRAD Deployments Have Decreased

In 1980, NWS, the Air Force, and FAA agreed to jointly deploy 175 NEXRAD units. However, they now plan to deploy 163 units. Most of these radars will be deployed by the end of fiscal year 1996. The reduction of 12, consisting of a net decrease of 13 outside CONUS and a net increase of one within CONUS, was due to changes to agency requirements, funding limitations, and military base closures. Table 2.3 provides a complete list of sites added to and deleted from the deployment plan and the reasons for these changes.

Also, FAA plans to place 5 of its 14 radars in storage until at least fiscal year 1997, and probably longer, because higher priority funding requirements are preventing FAA from paying the costs associated with deploying these radars. While these units are not located within CONUS, and thus do not affect NWS CONUS weather coverage, NWS officials said the radars are important to NWS' ability to issue timely and accurate forecasts and warnings. For instance, two of the radars located in the Caribbean would allow NWS to better track and monitor hurricanes as they approach the United States. However, NWS does not have a mission requirement for radar coverage outside CONUS.

NWS told GAO that the national radar coverage that is currently planned is equal to or better than existing coverage. However, the Secretary of Commerce, at the request of the House Committee on Science, Space, and Technology (now the House Committee on Science), commissioned NRC to study and report on the adequacy of proposed CONUS coverage compared to the existing coverage. The NRC study director said he expects the study to identify weaknesses in coverage and potential areas where additional radars may be needed. This report is to be issued in June 1995.

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### Unit Cost to Acquire Additional NEXRADs Could Be Much Higher

Included in the contract for the development and acquisition of NEXRADs is an option to purchase up to 20 additional NEXRADs through August 1996. However, this option is not priced, meaning that the unit cost for each

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additional radar is subject to negotiation. NEXRAD program office officials estimate that, depending on the number of radars that are needed, each radar could cost as much as three times the price of current units. These officials stated that the higher unit costs would be due to breaks in production.

Program officials said they agreed to an unpriced option because no firm requirements for additional radars existed at the time the contract was negotiated. The contractor did not price the optional units because of the uncertainty of future costs (e.g., the costs of restarting subcontractor production lines).

NWS has no plans to buy additional radars, and as a result, has not reassessed the cost-effectiveness of acquiring the more expensive radars. However, NRC is expected to report on national radar coverage that may warrant a reassessment of these plans.

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### Air Force NEXRADs Are Integral to NWS Mission Performance and Accessible to NWS Forecasters

The Air Force NEXRADs play a critical role in NWS' overall ability to issue complete and accurate weather forecasts and warnings. Seven of the 22 CONUS-based operational Air Force NEXRADs provide primary NWS radar coverage, according to NEXRAD program office officials. Also, the Air Force radars provide important backup coverage in the event that an NWS radar providing primary coverage for a given geographic area fails, and they provide supplemental views of severe weather patterns from different angles that strengthen NWS' watch and warning capabilities. The Air Force does not restrict NWS forecasters access to its radar data.

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### Air Force and NWS Radars May Not Be Available When Needed

The Air Force NEXRADs may not be available when information from them is needed. A key NEXRAD requirement is that each unit should be operationally available 96 percent of the time. However, 1994 and 1995 data show that only 38 to 90 percent of Air Force radars met this requirement each month, and in fact for 9 of these months no more than 70 percent of the sites met the requirement. Moreover, this situation could be much worse because the availability information that the Air Force has been reporting is unreliable. For instance, the Air Weather Service, which monitors the Air Force's NEXRAD operations, reported that the Eglin Air Force Base radar was available 100 percent of the time from September through December 1994, based on data from Air Force maintenance data collection systems. However, base radar officials told GAO that their radar's availability ranged from 78 to 87 percent per month for these 4 months.

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GAO found other examples of radar outages that were not reflected in Air Force availability data collected by the Air Weather Service.

In many cases, the Air Force NEXRAD operators and maintainers were not aware of the 96 percent availability requirement and, therefore, had no way of knowing that their performance was subpar. Inefficiencies in the Air Force's logistics process for obtaining spare parts have also made it difficult to meet availability requirements.

NWS also does not know if it is meeting the availability requirement for each of its units because it does not monitor availability on a site by site basis. Although NWS records radar downtime by site, it only uses this information to calculate the average availability of all sites, and it only monitors radar availability performance on this basis. It does not use this information to calculate and monitor site-specific availability. While GAO agrees that these aggregate data are useful in monitoring such things as spare parts usage and maintenance staffing trends, the data do not disclose whether each radar meets the required 96-percent availability requirement.

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## Recommendations

GAO recommends that the Secretary of Commerce direct the NOAA Assistant Administrator for Weather Services to

- not purchase additional radars to address any weaknesses in radar coverage that may result from the NRC study until assessing FAA's plans for deploying the five radars scheduled for storage and NWS' mission requirements for NEXRADs in these areas,
- ensure that any radars bought in response to NRC's national radar coverage findings are cost-beneficial, given that their unit cost could be substantially higher than those already purchased, and
- analyze and monitor system availability data on a site-specific basis for operational NEXRADs and correct any shortfalls in system availability that this analysis shows.

GAO also recommends that the Secretary of the Air Force direct the Air Force Director of Weather to improve the reliability of Air Force NEXRAD availability data and to correct any shortfalls that these data show.

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## Agency Comments

GAO received written comments on a draft of this report from the Departments of Commerce and Defense, and oral comments from senior

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FAA officials, including the NEXRAD program manager. Commerce's written comments are in appendix I, and Defense's written comments are in appendix II.

The Department of Commerce generally concurred with GAO's findings, conclusions, and recommendations, and stated that NWS is taking steps to analyze and monitor system availability on a site-specific basis. In a draft of this report, GAO proposed that the NOAA Assistant Administrator for Weather Services assess the operational impact of FAA delays in deploying the five radars and, on the basis of this assessment, take the necessary steps to ensure that NWS' radar coverage needs are met. In their comments, the Department of Commerce and the FAA NEXRAD program manager stated that NWS does not have a mission requirement for radars outside of CONUS. GAO has incorporated this comment in the section describing FAA plans for storing five radars and has revised the recommendation accordingly.

Commerce also partially concurred with the recommendation to ensure that any radars bought in response to NRC's coverage findings are cost-beneficial. However, Commerce requested that the recommendation be modified to reflect only NWS core mission and the Weather Service Modernization Act requirements. The NRC study director told GAO that its study will only address NWS' core mission and the act and GAO, therefore, did not modify its recommendation.

The Department of Defense concurred with GAO's recommendation concerning the Air Force, and stated that it will develop management actions to improve NEXRAD availability and the reliability of Air Force data.



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## Abbreviations

ASOS	Automated Surface Observing System
AWIPS	Advanced Weather Interactive Processing System
C4	Command, Control, Communications, and Computer
CONUS	conterminous United States
DOD	Department of Defense
FAA	Federal Aviation Administration
GAO	General Accounting Office
GOES-Next	Next Generation Geostationary Operational Environmental Satellite
NEXRAD	Next Generation Weather Radar
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NWS	National Weather Service
PUP	principal user processor
RDA	radar data acquisition
RPG	radar product generator



# Introduction

Accurate and timely weather forecasts and warnings are vital to the protection of life and property. Hundreds of lives and billions of dollars in property are lost every year as a result of thunderstorms, lightning, tornadoes, hurricanes, blizzards, and floods.

The National Weather Service's (NWS) basic mission is to provide weather and flood warnings, forecasts, and advisories for the protection of life and personal property. NWS operations also support other federal missions, such as aviation safety, and our nation's commercial interests, such as the agriculture industry. The Federal Aviation Administration (FAA) and the Air Force, besides being users of NWS data and information, also collect and analyze certain weather observations to support their respective missions. FAA, for example, collects and displays weather radar, cloud ceiling, and visibility data for its air traffic controllers to use.

Since the early 1980s, NWS has been modernizing its weather observing, information processing, and communication systems to predict the weather more accurately and quickly. This approximately \$4.5 billion modernization consists of four major system acquisitions and several smaller system upgrades and developments. FAA and the Department of Defense (DOD) are collaborating with NWS on two of these major acquisitions—the Next Generation Weather Radar (NEXRAD) and the Automated Surface Observing System (ASOS).<sup>1</sup> In addition to improved weather predictions, NWS expects the modernization to permit it to streamline its operations and downsize its organization without a degradation of service. For example, it expects to reduce its number of field offices from about 250 to 118 and to reduce staffing levels from 4,700 to 3,900.

## NEXRAD: A Brief Overview

NEXRAD is a Doppler radar<sup>2</sup> system that measures wind velocity in severe weather, tracks storm movement and intensity, and generates data and imagery for forecasters and other users, such as air traffic controllers. NEXRAD is expected to provide improved weather radar information, thus increasing the accuracy, timeliness, and credibility for warnings of severe thunderstorms, tornadoes, flash floods, turbulence, wind shear, and other types of hazardous weather and related events. The radars are also

<sup>1</sup>The other two major system acquisitions are the Advanced Weather Interactive Processing System (AWIPS) and the Next Generation Geostationary Operational Environmental Satellite (GOES-Next).

<sup>2</sup>Doppler radar is used to determine the speed and direction of rain or snow particles, cloud droplets, or dust moving toward or away from the radar. The radar accomplishes this by sending out a pulse using a stable frequency and then measuring the changing frequencies as the distances between the radar and the object changes.

expected to be extremely useful in analyzing a variety of other weather events, including estimating accumulated rainfall and analyzing large-scale precipitation systems.

NEXRAD is being acquired jointly by NWS, the Air Force, and FAA. The three agencies currently plan to purchase and deploy 163 NEXRADs—119 for NWS, 30 for the Air Force, and 14 for FAA—at an estimated cost of just over \$1.4 billion—\$860 million from NWS, \$264 million from the Air Force, and \$293 million from FAA.<sup>3</sup>

Of the 163 NEXRADs, 144 are to be located within the conterminous United States (CONUS),<sup>4</sup> 11 are to be located in Hawaii and Alaska, and 8 are to be located in the Caribbean, the Atlantic, the Pacific, and Korea. Data from these radars are shared among the three agencies to support their respective missions. For example, NWS needs adequate CONUS coverage to issue timely and accurate forecasts and warnings, and uses data from several Air Force NEXRADs to fill some gaps in coverage. Likewise, the Air Force and FAA rely on NWS radars in addition to their own to support their respective national defense and aviation missions.

On the basis of the three agencies' collective mission needs and the Weather Service Modernization Act, which mandates that the Secretary of Commerce certify that there will be no degradation in radar coverage at the 10,000 foot level prior to closing, consolidating, automating, or relocating any of NWS' field offices, the three agencies negotiated the radars' locations to meet tri-agency radar coverage requirements.<sup>5</sup> The locations of all CONUS radars are shown in figure 1.1.

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<sup>3</sup>The Air Force and FAA totals cover their respective NEXRADs and 2.7 percent and 20 percent, respectively, of NWS' NEXRADs due to a cost sharing arrangement agreed to by the three agencies.

<sup>4</sup>CONUS consists of all the States except Alaska and Hawaii.

<sup>5</sup>The 10,000 foot level is significant because this is the elevation at which the coverage range of an individual NEXRAD is measured. The ascending radar beam loses its reliability about 125 miles from the radar. At this distance the lowest part of the beam is approximately 10,000 feet off the ground. Therefore, each radar has a coverage diameter of 250 miles. The 250 mile cylinders were the basis for siting NEXRADs to ensure adequate CONUS coverage.

**Figure 1.1: Locations of NEXRADs Within CONUS**



Chapter 1  
Introduction





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## NEXRAD History and Status

In 1980, NWS, the Air Force, and FAA agreed to jointly develop and acquire 175 NEXRADs. By 1987, production of a limited number of NEXRAD units had been approved. By 1990, the contractor, Unisys, began experiencing development problems. Unisys was behind schedule, cost estimates were overrun, and specified performance requirements were not being met. Commerce's National Oceanic and Atmospheric Administration (NOAA), of which NWS is a part, raised serious concerns about the contractor's ability to complete the contract. NOAA's concerns focused on cost, schedule, and performance issues, and on Unisys' financial condition. According to a program manager at that time, Unisys underbid the contract. These issues led to NOAA suspending the radar deliveries and considering contract termination.

To address this dilemma, NOAA evaluated the pros and cons of (1) reaching a comprehensive settlement with Unisys to deliver radar systems or (2) terminating the existing contract and contracting with another vendor. After analyzing both choices, NOAA and Unisys signed a comprehensive settlement of contractual issues in August 1991, renegotiated the contract, and the production of radars resumed. The renegotiated contract included a \$182 million increase in the contract cost. The associated increase in the unit cost of the NEXRADs forced the Air Force to drop 13 units to remain within its program funding limits.

As of February 1995, 107 radars had been deployed—81 by NWS, 22 by the Air Force, and 4 by FAA. The final NEXRAD deployment is scheduled for June 1996. By September 1995, the three agencies are expected to have collectively spent \$1.2 billion.

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## NEXRADs Contain Three Major Components

Each NEXRAD consists of three major subsystems—the radar data acquisition (RDA) subsystem, the radar product generator (RPG) subsystem, and the principal user processor (PUP) subsystem—and associated communications among these subsystems. Each NEXRAD includes about 400,000 lines of code for operating the radar, processing radar signals, generating and transmitting data, and displaying data products.

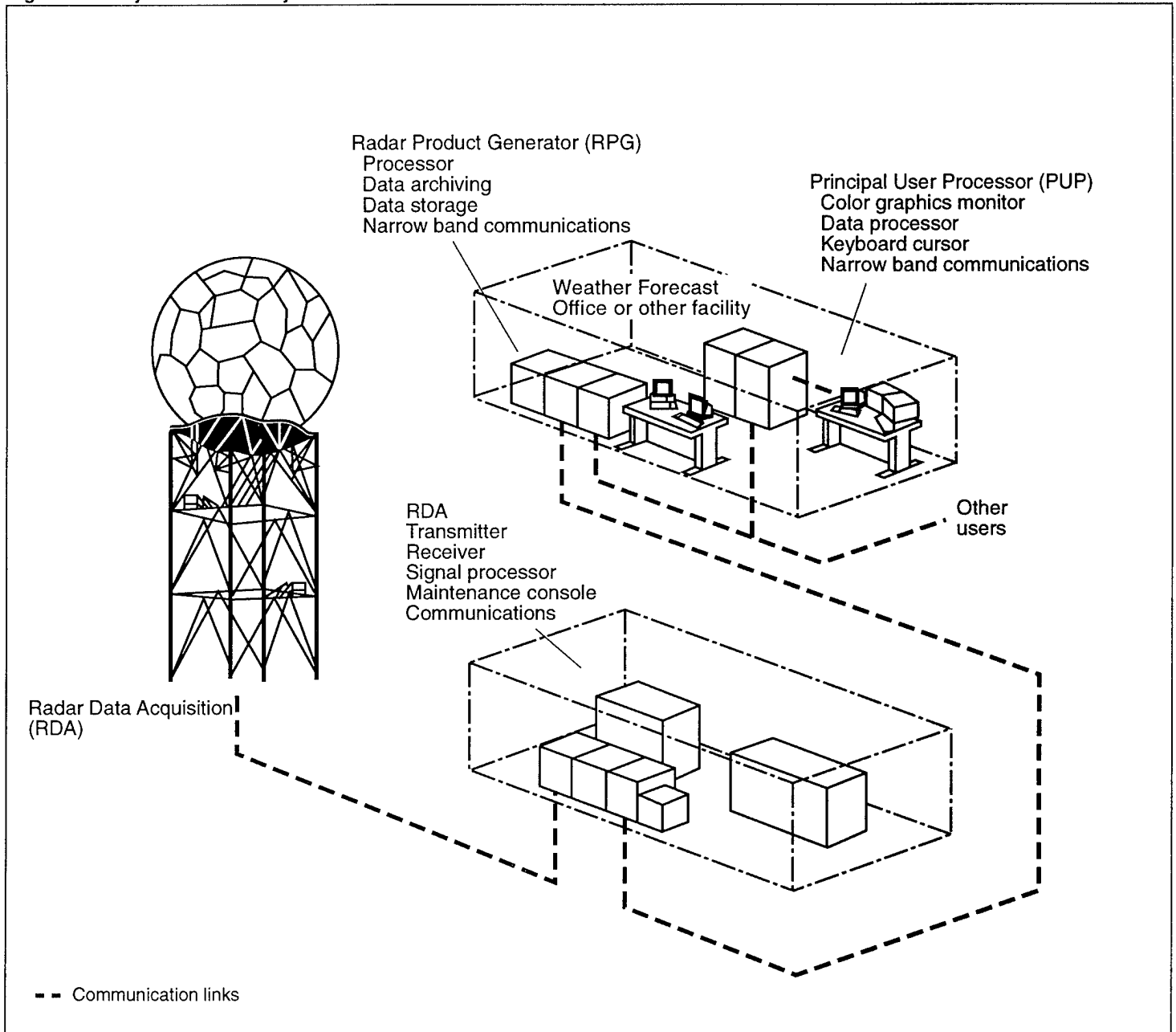
The RDA consists of a 10 centimeter wavelength Doppler weather radar that collects the raw data to, among other things, (1) measure wind velocity in severe weather, (2) provide improved estimates of precipitation amounts, and (3) track storm movement and intensity. The technology needed to perform this function includes an antenna, pedestal, radome (a dome-shaped covering to protect the antenna), transmitter, and receiver.

Included in the RDA unit is hardware and software necessary for a variety of control functions, including signal processing, monitoring, and error detection, as well as archiving the radar data. A computer processes the radar signals to create digital data that can be further processed by the RPG.

The RPG includes all hardware and software necessary for turning the data into displayable data products. Specifically, the RPG provides real-time generation, storage, and distribution of products for users. It includes hardware and software required for system control; status monitoring; and error detection, archiving, and data processing.

The PUP is a workstation that consists of the hardware and software required for the request, display, local storage and annotation, and distribution of products by forecasters. It also includes the hardware and software required for local control, status monitoring, archiving, and communicating with other users. The PUP maintains a dedicated communication link to the RPG located on-site, and it routinely receives NEXRAD products. The PUP also has the capability to access data from RPGs at other NEXRAD sites. In addition, under an NWS administered NEXRAD information dissemination service, NWS has set aside four communications ports to allow access by commercial companies that provide data to other government agencies and the public. Figure 1.2 shows the key NEXRAD subsystems for a typical NWS weather forecast office.

Figure 1.2: Key NEXRAD Subsystems



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## Program Management and Organization

The NEXRAD Joint Systems Program Office, hereafter referred to as the program office, organizationally resides within NOAA and is responsible for managing the acquisition of the radars. The program office is staffed and funded by the three participating agencies. The radars are to be purchased, operated, and maintained by the respective acquiring agency, but information from each radar is to be shared among all three.

NWS' Office of Systems Operations will assume program management responsibility from the program office once all NEXRADs have been delivered. In addition, the Operational Support Facility provides technical support for operating and maintaining radar equipment. To ensure that the needs of all three agencies are met, both the program office and the Operational Support Facility are jointly staffed and funded by NWS, the Air Force, and FAA. NWS' National Logistics Supply Center in Kansas City, Missouri, will be the centralized NEXRAD depot and repair center for all three agencies' radars.

The Air Force owns all of DOD's NEXRADs, including four radars that are located at Army locations.<sup>6</sup> The Director of Weather, Office of the Deputy Chief of Staff, Plans, and Operations, within the Air Force, is responsible for planning, programming, and budgeting for weather support. The Director of Weather's responsibilities include publishing weather policy<sup>7</sup> and standardized procedures, and assessing the technical performance and effectiveness of Air Force weather support, including those associated with NEXRAD. The Director of Weather disseminates weather policy through the Air Force major commands,<sup>8</sup> which in turn distribute it to the Air Force bases responsible for the individual NEXRAD units. The Air Force is responsible for operating and maintaining DOD NEXRADs. The Air Force's Air Weather Service is the lead organization for oversight of all Air Force NEXRADs.

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## Objectives, Scope, and Methodology

The objectives of our review were to determine (1) the NEXRAD units that were dropped from the original deployment plan and the reasons they were dropped, (2) the feasibility and estimated cost of extending the NEXRAD contract to purchase additional radars, (3) the Air Force NEXRADs'

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<sup>6</sup>The Air Force owns the RDAs and RPGs associated with each DOD NEXRAD. The PUPs are owned by the Air Force, Navy, and Army since all services are users of the weather data.

<sup>7</sup>Weather support policy is established in the Office of the Chief of Staff of the Air Force.

<sup>8</sup>These commands include (1) Air Combat Command, (2) Air Education and Training Command, (3) Air Mobility Command, (4) Air Force Material Command, (5) Space Command, and (6) Pacific Air Forces.

contribution to the national NEXRAD network and the accessibility of the Air Force NEXRAD data to civilian forecasters, and (4) the availability of the Air Force and NWS radars. Generally, our methodology was guided by those sections of GAO's System Assessment Framework pertaining to operational systems. A detailed description of our methodology follows.

To determine which units have been dropped from the original deployment schedule and why they were dropped, we met with NEXRAD program officials to obtain the original and current deployment schedules, discuss which units were dropped or added to the deployment schedule, and identify the reasons why. In addition, we reviewed documentation on the 1991 comprehensive settlement, since this settlement led to the majority of the deployment changes. Finally, we verified our analysis of the units affected and the reasons why with NEXRAD program officials. We did not identify the impact of these changes because the National Research Council (NRC) is currently reviewing the adequacy of proposed NEXRAD CONUS coverage in terms of the "no degradation of service" requirement of the Weather Service Modernization Act.<sup>9</sup>

To determine the feasibility and estimated cost of extending the NEXRAD contract to purchase additional radars, we reviewed the current contract option for additional radars. Since this option is unpriced, we obtained the program office's per unit cost estimate of acquiring radars if this option was exercised and compared this estimate to an oral estimate that the contractor provided to the program office.

To determine the Air Force NEXRADs' contribution to the national network, we reviewed the Federal Meteorological Handbook Number 11, published by the Office of the Federal Coordinator for Meteorology, to identify the types of data Air Force radars provide to NWS. In addition, we interviewed NWS and program officials to determine how NWS accesses and uses the Air Force radar data, and the impact of NWS not having the Air Force radar data. To determine the accessibility of the Air Force NEXRAD data to civilian forecasters, we interviewed program office, NWS, and Air Force officials about potential data restrictions.

To determine the availability of the Air Force radars, we collected and reviewed availability data from the Air Force and NWS operational NEXRAD

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<sup>9</sup>At the request of the House Committee on Science, Space, and Technology (now the House Committee On Science), the Secretary of Commerce commissioned this review by NRC's NWS Modernization Committee to ensure that NWS complies with the Weather Service Modernization Act (Public Law 102-567), which requires, among other things, that the Secretary of Commerce certify that there is no degradation of service resulting from office closures associated with the modernization.

units and compared these data to the availability requirement specified in the NEXRAD Joint Operational Requirements document. We also interviewed officials from the Air Force's Air Weather Service at Scott Air Force Base near St. Louis, Missouri; the Air Force's Air Combat Command in Hampton, Virginia; NWS' Operational Support Facility and Weather Forecast Office in Norman, Oklahoma; and seven DOD bases that operate and maintain NEXRADs.

We performed our work primarily at the NEXRAD program office, and NOAA and NWS headquarters in Silver Spring, Maryland. Our work was performed from October 1994 to May 1995, in accordance with generally accepted government auditing standards.

As requested, the Departments of Commerce and Defense provided written comments on a draft of this report. These comments are in appendixes I and II. We obtained oral comments from senior FAA officials, including the NEXRAD program manager. The comments from Commerce, Defense, and FAA are presented and evaluated throughout the report.

# NEXRAD Deployments Have Been Reduced and Delayed Because of Requirements Changes, Budget Constraints, and Base Closures

NWS, the Air Force, and FAA plan to meet their needs by deploying 163 NEXRADs worldwide, 12 less than the 175 originally planned. This decrease is due to changes in agency requirements, funding limitations, and military base closures. It includes a net decrease in deployments outside of CONUS of 13 and a net increase in CONUS deployments of 1. NRC is currently studying the adequacy of proposed NEXRAD CONUS coverage. The NRC study director said he expects the study to identify weaknesses in coverage and potential areas where additional radars may be needed.

Most of the 163 radars are to be deployed by the end of fiscal year 1996. However, FAA plans to delay deploying five of its radars until at least fiscal year 1997 because of budget constraints. While these radars are outside CONUS, NWS officials said they are important to NWS' ability to track and forecast severe weather.

## Global NEXRAD Deployments Decreased by 12

In November 1991, plans for deploying 13 Air Force and 3 FAA radars were canceled as part of the comprehensive settlement with the NEXRAD contractor. The 16 radars were disposed of by selling 1 radar back to Unisys; using 2 radars for new DOD and FAA requirements; using portions of 3 for NWS training, research, and maintenance activities; using portions of 6 systems to provide redundant hardware at remote locations in order to have backups on hand should equipment fail; and converting the remaining 4 systems to spares.

Since the comprehensive settlement, NWS has added three radars and FAA has added one. In addition, the Air Force has added a requirement for one radar, deleted the requirement for another, and transferred ownership of one of its radars to NWS. The net result is the reduction of 12 NEXRADs. According to program officials, the 163 remaining radars will still satisfy the three agencies' collective requirements and provide radar coverage equal to or better than the existing service. Table 2.1 summarizes the three agencies' respective changes to the deployment plan.

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**Table 2.1: Changes to Worldwide  
NEXRAD Plan by Agency**

Agency	Original deployment plan	Comprehensive settlement changes	Additional changes	Current deployment plan <sup>a</sup>
NWS	115	0	+4 <sup>b</sup>	119
Air Force	44	-13	-1 <sup>c</sup>	30
FAA	16	-3	+1 <sup>d</sup>	14
<b>Total</b>	<b>175</b>	<b>-16</b>	<b>+4</b>	<b>163</b>

<sup>a</sup>These figures include three NWS and three Air Force systems used for training, research, and logistics purposes.

<sup>b</sup>NWS added NEXRADs at (1) Greer, South Carolina, (2) Jackson, Kentucky, and (3) the NOAA National Severe Storms Laboratory in Norman, Oklahoma. Also, NWS assumed ownership of an Air Force NEXRAD because Loring Air Force Base, Maine, is closing.

<sup>c</sup>The Air Force canceled the NEXRAD scheduled for Nellis Air Force Base, Nevada. It added a NEXRAD at Fort Polk, Louisiana. It also transferred ownership of the NEXRAD at Loring Air Force Base, Maine, to NWS.

<sup>d</sup>FAA added a NEXRAD at South Shore, Hawaii.

## CONUS NEXRAD Deployments Increased by One

NEXRAD deployments within CONUS originally totaled 143. These deployments now total 144. The net increase of one radar is the result of an assortment of Air Force and NWS deployment changes over the last 4 years that reduced Air Force NEXRADs by three and increased NWS radars by four. Specifically, the Air Force eliminated the requirement for two radars as part of the November 1991 settlement with the contractor. Later, NWS added four radars, and the Air Force dropped an additional radar. FAA never planned to deploy any of its radars within CONUS. Table 2.2 summarizes the agencies' respective changes to the original CONUS deployment plan.



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**Table 2.2: Changes to NEXRAD Plan Within CONUS by Agency**

Agency	Original deployment plan	Comprehensive settlement changes	Additional changes	Current deployment plan <sup>a</sup>
NWS	115	0	+4 <sup>b</sup>	119
Air Force	28	-2 <sup>c</sup>	-1 <sup>d</sup>	25
FAA	0	0	0	0
<b>Total</b>	<b>143</b>	<b>-2</b>	<b>+3</b>	<b>144</b>

<sup>a</sup>These figures include three NWS and three Air Force systems used for training, research, and logistics purposes. NWS and the Air Force will deploy 116 and 22 CONUS-based operational systems respectively.

<sup>b</sup>NWS added NEXRADs at (1) Greer, South Carolina, (2) Jackson, Kentucky, and (3) the NOAA National Severe Storms Laboratory in Norman, Oklahoma. Also, NWS assumed ownership of an Air Force NEXRAD because Loring Air Force Base, Maine, is closing.

<sup>c</sup>The Air Force canceled NEXRADs scheduled for Grissom Air Force Base, Indiana, and England Air Force Base, Louisiana, due to projected base closures.

<sup>d</sup>The Air Force canceled the NEXRAD scheduled for Nellis Air Force Base, Nevada. It also added a NEXRAD at Fort Polk, Louisiana, and transferred ownership of the NEXRAD at Loring Air Force Base, Maine, to NWS.

## NEXRAD Deployment Changes Due to Budget Constraints, Requirement Changes, and Base Closures

In total, 23 changes have been made to the original NEXRAD deployment schedule. Of these 23, 9 changes were made because budget constraints prevented the purchase of planned radars;<sup>1</sup> 9 were because the requirement for a radar at a given site was deleted or a new requirement was added;<sup>2</sup> 4 were because the military base that was to receive the radar was identified for closure; and 1 was because the frequency over which the radar's signal is transmitted was unavailable at the planned overseas deployment location.

Of the 23 changes, 3 related to NWS radars, 16 related to Air Force radars (11 overseas), and 4 related to FAA radars. Table 2.3 identifies the changes by agency, sites affected, type, and reason for each of the 23 changes.

<sup>1</sup>These budget constraints arose because radar unit cost increases associated with the comprehensive settlement prevented the Air Force from buying as many radars as originally planned while still staying within its program budget.

<sup>2</sup>Program office officials stated that FAA and the Air Force deleted requirements for three and one radars, respectively, because justification for the original requirements was later invalidated.

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**Table 2.3: Locations of and Reasons for Changes in NEXRAD Deployment Schedule**

Agency	Site	Change	Reason
Air Force	Central Germany	Deletion	Budget constraint
Air Force	Eastern Germany	Deletion	Budget constraint
Air Force	Western Germany	Deletion	Budget constraint
Air Force	Aviano Air Base, Italy	Deletion	Budget constraint
Air Force	Crotone Air Base, Italy	Deletion	Budget constraint
Air Force	Camp New Amsterdam, Netherlands	Deletion	Budget constraint
Air Force	Zaragoza Air Base, Spain	Deletion	Budget constraint
Air Force	East United Kingdom	Deletion	Budget constraint
Air Force	West United Kingdom	Deletion	Budget constraint
Air Force	Clark Air Base, Philippines	Deletion	Base closure
Air Force	Yokota Air Base, Japan	Deletion	Frequency unavailable
Air Force	England Air Force Base, Louisiana	Deletion	Base closure
Air Force	Grissom Air Force Base, Indiana	Deletion	Base closure
Air Force	Nellis Air Force Base, Nevada	Deletion	Requirement deleted
Air Force	Fort Polk, Louisiana	Addition	New requirement
Air Force	Loring Air Force Base, Maine	Transfer	Base closure
FAA	McGrath, Alaska	Deletion	Requirement deleted
FAA	Bering Sea, Alaska	Deletion	Requirement deleted
FAA	Site to be determined	Deletion	Requirement deleted
FAA	South Shore, Hawaii	Addition	New requirement
NWS	Greer, South Carolina	Addition	New requirement
NWS	Jackson, Kentucky	Addition	New requirement
NWS	National Severe Storms Laboratory, Norman, Oklahoma	Addition	New requirement

## NRC Is Studying the Adequacy of Planned NEXRAD Coverage

According to NWS, the current tri-agency plan for deploying 138 operational NEXRADs within CONUS will provide radar coverage equal to or better than existing coverage. However, at the request of the House Committee on Science, Space, and Technology (now the House Committee on Science), the Secretary of Commerce commissioned an independent review of NEXRAD CONUS coverage. The Committee did this to ensure that NWS complies with the Weather Service Modernization Act, which requires,

among other things, that the Secretary of Commerce certify that the modernization result in no degradation in service.

The Secretary of Commerce asked the NRC Committee on National Weather Service Modernization to perform this study. The NRC study director said he expects the study, which NRC plans to issue in June 1995, to identify potential areas where coverage is degraded and where additional radars may be needed. Because of NRC's study, we did not address the impact of the reduced number of radars on the three agencies' radar coverage objectives.

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## Five FAA NEXRADs to Be Placed in Temporary Storage

FAA currently plans to place 5 of its 14 NEXRADs in storage for probably more than a year because deploying the radars is not a funding priority.<sup>3</sup> The five FAA NEXRADs are paid for and scheduled for delivery around June 1996. However, FAA's fiscal year 1996 budget request does not include the \$18 million needed to deploy them. According to the FAA program manager for NEXRAD, the earliest that FAA may request funds is fiscal year 1997; however, the program manager does not expect funding approval at that time. The program manager attributed the funding shortfall to deployment costs that were higher than expected.

NWS did not plan to place NEXRADs in these locations because NWS does not have a mission requirement for radar coverage outside CONUS. However, according to NWS officials, data from planned NEXRADs in Alaska, Hawaii, and the Caribbean will be used by NWS to enhance its ability to provide timely and accurate forecasts and warnings. For instance, according to the NOAA Assistant Administrator for Weather Services, two of these radars in the Caribbean would allow NWS to better track and monitor hurricanes approaching the United States. Despite NWS' desire to have radars in these areas, the NOAA Assistant Administrator for Weather Services stated that should FAA decide not to deploy these radars, he is not sure whether NWS would choose to do so.

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## Conclusions

NRC is expected to identify weaknesses in NEXRAD's national coverage that may suggest that NWS buy additional radars. However, five FAA radars planned for Alaska, Hawaii, and the Caribbean are paid for and will be warehoused indefinitely. While NWS does not have a mission requirement for radars in these locations, NWS officials stated that radars in these

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<sup>3</sup>The five sites are (1) Georgetown, Bahamas, (2) Grand Turk, British West Indies, (3) South Shore, Hawaii, (4) Kohala, Hawaii, and (5) Nome, Alaska.

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geographic areas would enhance its ability to provide forecasts and warnings. Consequently, NWS is uncertain whether it would choose to deploy radars in these areas should FAA decide not to.

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## Recommendation

We recommend that the Secretary of Commerce direct the NOAA Assistant Administrator for Weather Services to not purchase additional radars to address any weaknesses in radar coverage that may result from the NRC study until assessing FAA's plans for deploying the five radars scheduled for storage and NWS' mission requirements for NEXRADs in these areas.

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## Agency Comments and Our Evaluation

In a draft of this report, we proposed that the NOAA Assistant Administrator for Weather Services assess the operational impact of FAA's delays in deploying the five radars and, on the basis of this assessment, take the necessary steps to ensure that NWS radar coverage needs are met. Both the Department of Commerce and the FAA NEXRAD program manager stated that NWS does not have a mission requirement for radars outside CONUS. We have incorporated these comments in the section describing FAA's plans for storing five radars and subsequently revised our recommendation in this chapter.

The Department of Commerce also stated that we did not accurately characterize the NRC study. Commerce stated the NRC study is of proposed NEXRAD radar coverage and consolidation of field offices to ensure the "no degradation of service" requirement of the Weather Service Modernization Act. We have clarified references to the NRC study in our report to state that the study is of proposed NEXRAD coverage as compared to premodernization radar coverage.

Commerce also noted that NOAA believes that the currently planned NEXRAD network will provide radar coverage equal to or better than the existing service, and that NOAA is aware of gaps in modernized radar coverage. Our report has been modified to reflect this.

Commerce also stated that the number of systems to be purchased and deployed still stands at 175, rather than the 163 we reported. It explained the disposition of the radars resulting from the comprehensive settlement. We agree with this explanation and have added a clarifying statement in this chapter. However, the number of systems to be deployed is 163. This number, which is based on our review of the NEXRAD deployment schedule, is consistent with program office documentation and with the total

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presented by the Under Secretary for Oceans and Atmosphere, before the Senate Subcommittee on Science, Technology, and Space, Committee on Commerce, Science, and Transportation in his January 31, 1995, testimony.

# Unit Cost of Any Additional NEXRADs May Be Substantially Higher

The program office has the option to buy up to 20 additional NEXRADs through August 1996 or the date that the last radar is delivered, whichever occurs first. However, this option is not priced, meaning that it is subject to negotiation. Program officials estimate that if the option was exercised, the unit cost could be as much as three times the cost of those currently under contract.<sup>1</sup> Because the program office has no current plans for buying additional radars, it has not reassessed the cost-effectiveness of the more expensive radars. However, as mentioned in chapter 2, NRC's study is expected to report on gaps in NEXRAD national coverage that could suggest the purchase of more radars via this contract option.

## Additional NEXRADs May Cost as Much as Three Times Current Costs

The program office agreed to an unpriced option because no firm requirements for additional radars existed at the time the current contract option was negotiated. Further, the contractor opposed pricing the option because of the uncertainty of future costs, such as restarting production lines. According to program officials, the contractor would not agree to a priced option without knowing how many or when additional radars would be ordered.

While the price of the additional NEXRADs, should they be required, will ultimately be subject to negotiation, the program office estimates that the hardware and software costs for each radar could be as much as three times that of the mean cost of radars currently under contract. The program office based this estimate on a recently expired, priced contract option that had a not-to-exceed price. It then factored in additional costs due to breaks in production. These disruptions increase costs because the longer the government waits to exercise the option, the greater the chances that the contractor and its subcontractors will have shut down part or all of their production lines and started work for other clients. According to program officials, this has already occurred as the subcontractor responsible for the transmitter has closed its production line.

The program office estimate is consistent with a nonbinding, verbal estimate that the contractor provided to the program office. This contractor estimate, however, assumed that the option would be exercised in the first quarter of fiscal year 1995. Exercising the option later, according to program officials, would result in a higher unit cost. In addition, the program office based its estimate on the purchase of 12

<sup>1</sup>The actual unit cost estimate is not disclosed in this report because the information may be acquisition sensitive.

radars. Purchasing fewer radars would also increase the unit cost because manufacturing start-up costs for a smaller order would be allocated over fewer units.

Office of Management and Budget Circular A-11<sup>2</sup> requires that agencies use benefit-cost analyses to evaluate contemplated investments in information technology. The purpose of these analyses is to maximize an agency's return on its information technology dollar. In addition, these analyses are not to be one-time exercises performed at the beginning of a project. Instead, it is fiscally prudent to redo these analyses whenever expected benefits or estimated costs change significantly. Without reassessing a system's payback in the event of sizeable cost growth, poor investment decisions can result.

As mentioned in chapter 2, weaknesses in NEXRAD's national coverage that are identified by NRC may suggest that NWS buy additional radars. Should this occur, the existing contract option would be an available vehicle for doing so, subject to applicable procurement regulations. The program office has not assessed the cost-effectiveness of purchasing the additional units because currently no requirements exist for additional radars. If this changes, program officials agreed that it would be wise in deciding whether or not to exercise the contract option, to reassess the benefits to be derived from the additional radars against their higher cost.

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## Conclusion

Additional NEXRADs could cost as much as three times more than units currently under contract. At this price, the radars' benefits may not exceed their cost, and thus buying more may not be worth the investment. While NWS officials acknowledged the value in reassessing the benefits versus the costs of the more expensive radars before exercising the NEXRAD contract option, they did not commit to doing so since requirements for additional radars currently do not exist.

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## Recommendation

We recommend that the Secretary of Commerce direct the NOAA Assistant Administrator for Weather Services to ensure that any radars bought in response to NRC's national radar coverage findings are cost-beneficial, given that their unit cost could be substantially higher than those already purchased.

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<sup>2</sup>Preparation and Submission of Budget Estimates, July 1994.

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## Agency Comments and Our Evaluation

In its comments, the Department of Commerce partially concurred with our recommendation to ensure that any radars bought in response to NRC's coverage findings are cost-beneficial. Commerce agreed that the requirements to procure additional radars need to be justified; however, it requested that the recommendation be modified to reflect only NWS' core mission and the Weather Service Modernization Act requirements. The NRC study director told us that the act was used as criteria in its evaluation. We, therefore, did not modify our recommendation.

In addition, Commerce stated that while the existing contract option is an available vehicle for buying additional radars should the need arise, it is by no means obvious that this vehicle would be exercised. Commerce added that under federal acquisition regulations, the government would have to determine the best approach for acquiring additional systems. We have modified the report to address these concerns.



# Air Force NEXRADs Are Integral to NWS Mission Performance and Accessible to NWS Forecasters

The Air Force's NEXRADs play an integral role in NWS' ability to issue accurate and timely weather forecasts and warnings. These radars, which provide essential primary, backup, and supplemental coverage, are vital in supporting the NWS CONUS-based network. Seven of the 22 CONUS-based operational Air Force NEXRADs provide primary NWS radar coverage. The Air Force NEXRADs also provide backup coverage in the event an NWS NEXRAD is not operating, according to NWS officials. Further, the Air Force NEXRADs augment other NEXRADs by covering severe weather events from different angles, thus strengthening NWS' watch and warning capabilities by providing additional insights into the event's behavior. To illustrate, the Altus Air Force Base NEXRAD in Frederick, Oklahoma, is critical to coverage in parts of Oklahoma and Texas because adjacent NWS radars reach only marginally into these areas.

NWS has unrestricted access to all Air Force, CONUS-based NEXRAD products. According to a tri-agency agreement, all NEXRADs "shall be operated to satisfy the integrated needs of all three agencies." Further, each agency is to "support, to the maximum extent possible, the data, products, and operational requirements of the others, consistent with the capabilities and mission priorities of that agency." All CONUS Air Force sites are specifically required to "provide assistance to NWS offices by providing access to weather radar data for gaps in the National Weather Radar Network."

NWS' access to the Air Force's CONUS-based NEXRADs is accomplished via dedicated and dial-up communication lines. Currently, 13 weather offices have dedicated lines to Air Force NEXRADs. The 13 offices are generally the closest ones geographically to the Air Force radars. These dedicated lines operate at 9.6 kilobits per second. Each Air Force NEXRAD also provides three to four dial-up communication ports for use by other NWS field offices. These lines are also 9.6 kilobits per second and are reserved for NWS use.

## Agency Comments and Our Evaluation

In its comments, the Department of Commerce agreed that the Air Force NEXRADs are essential to NWS' ability to issue quality forecasts and warnings, and that our report adequately describes most of the meteorological aspects of this need. However, Commerce stated that the Air Force's radars need to be reconfigured to accept input from real-time rain gauges to meet the needs of the River Forecast Centers. Although we understand NWS' desire for all Air Force CONUS-based NEXRADs to accept input from rain gauges, the tri-agency agreement does not establish a

requirement for Air Force NEXRADs to perform this function. The agreement states that a CONUS-based Air Force NEXRAD "shall not execute the rain gauge data acquisition function." We confirmed with NWS officials that the rain gauge data acquisition function is still not an Air Force NEXRAD requirement.

In its comments, the Department of Defense disagreed with our conclusion on the role Air Force radars play in the National Weather Radar Network. Specifically, Defense disagreed with our use of the term backup when associated with the Air Force's radars, because it implies that the Air Force's radars are integral parts of the national network. Defense stated that the tri-agency documentation defines NWS' radars as network sites and the Air Force's as supplemental sites, and that therefore we should not refer to the Air Force CONUS-based NEXRADs as backup systems, but rather as supplemental sites.

We have decided not to use the term supplemental when referring to these Air Force radars because they provide primary, backup, and supplemental coverage. For example, the tri-agency documentation specifically states that CONUS-based supplemental Air Force sites are to "provide assistance to NWS offices by providing access to weather radar data for gaps in the National Weather Radar Network." Today, 7 of the 22 CONUS-based operational Air Force NEXRADs provide the sole radar coverage for certain geographic areas. NWS officials also told us that NWS uses data from Air Force NEXRADs to provide backup coverage and to supplement data from their NEXRADs, as well as to provide primary coverage. On the basis of this combination of primary, backup, and supplemental coverage, the Air Force CONUS-based NEXRADs contribute considerably to the national NEXRAD network and are indeed integral parts of the national network.

# Air Force and NWS NEXRADs May Not Be Available When Needed

To effectively support NWS' requirements for CONUS radar coverage, it is important that the Air Force's NEXRADs meet all specified requirements. However, Air Force data show that some of its radars are performing below the tri-agency system availability requirement. Moreover, because Air Force availability data are unreliable and appear to be overstated, it is uncertain whether any of its radars are meeting availability requirements. Opportunities exist to improve Air Force NEXRAD availability performance by increasing radar operator awareness of the availability requirement and streamlining the spare parts logistic process. In addition, because NWS currently does not calculate and monitor availability by site, there is no way to determine whether each NWS NEXRAD is meeting the availability requirement.

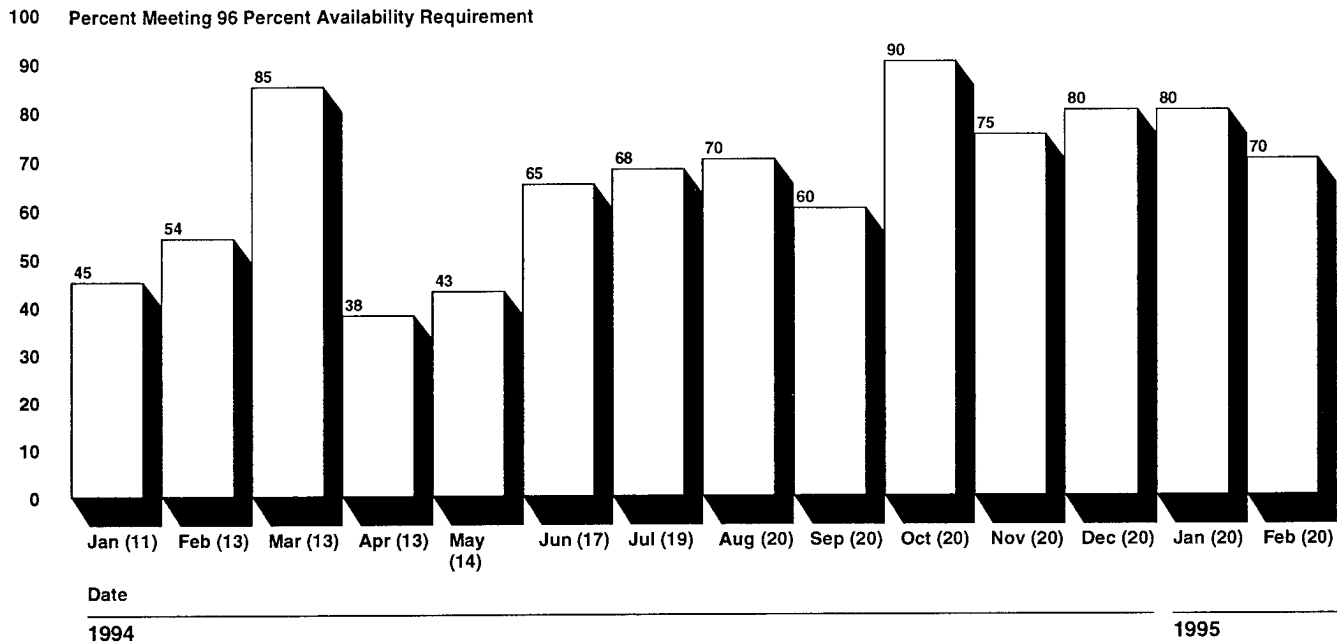
## Air Force NEXRADs Are Not Meeting System Availability Requirements

NWS, the Air Force, and FAA have specified that each NEXRAD unit must be operationally available 96 percent of the time.<sup>1</sup> According to NWS officials, the 96 percent requirement is based on an analysis that considered factors such as equipment reliability, staff costs, and spare parts costs. These officials stated that the additional costs (for example, redundant systems, spare parts, and additional maintenance technicians) associated with achieving availability above 96 percent were not worth the added benefits.

Many of the Air Force's NEXRADs are not meeting the 96-percent availability requirement. Since January 1994, the reported percent of operational Air Force NEXRADs meeting this requirement each month has ranged from 38 to 90 percent (see figure 5.1).

<sup>1</sup>The NEXRAD Joint Operational Requirements define availability as the time that the system is operating satisfactorily, expressed as a percentage of total time (the time the system is operating satisfactorily plus the time the system is down). Downtime includes corrective and preventive maintenance time and delays encountered due to the delivery of needed spare parts. Most definitions of availability exclude scheduled downtime, such as preventive maintenance.

Figure 5.1: Number of Air Force NEXRADs Meeting 96-Percent Availability Requirement



Note: Numbers in parentheses indicate the number of Air Force NEXRADs in operation.

However, the data upon which these availability statistics are based are unreliable and appear to be overstated. For example, the Air Force data provided by the Air Weather Service show that nine NEXRADs have been operationally available 100 percent of the time for 4 or more consecutive months. This is highly unlikely considering that, according to NWS' Chief Logistician, the radars are likely to fail an average of 52 times a year, or about 4 times per month. We contacted six of the nine sites reporting 4 or more consecutive months of 100 percent availability and found that three of the sites had significant outages during this time. For example, data for Eglin Air Force Base show 100 percent availability for September through December 1994, but Eglin radar officials stated that their radar was available for these 4 months only 87, 78, 79, and 87 percent of the time, respectively. Similarly, data for Dyess Air Force Base show 100 percent availability for February 1995, but Dyess officials stated that their radar was available only 81 percent of the time in February 1995. Also, data for

Robins Air Force Base show 100 percent availability for September 1994, but Robins officials stated that their radar was unavailable for 12 days in September 1994 while they were waiting for a replacement part.

According to an internal Air Force report dated October 1994,<sup>2</sup> the availability data inconsistencies are not unique to NEXRAD, but rather extend to all Air Force command, control, communications, and computer (C4) systems. The report stated that not all system performance data are being collected and reported on C4 systems. This occurs, according to the report, because C4 personnel do not adequately understand and are not sufficiently trained in the maintenance data collection process and because the systems collecting and reporting the performance data have software problems that have gone unchecked. The report recommends that the Air Force establish a team to address these problems.

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## Air Force NEXRAD Operators and Maintainers Are Unaware of the Tri-Agency Availability Requirement

Air Force operators and maintainers are unaware of the 96-percent availability requirement and, therefore, have no way of knowing if actual radar performance is satisfactory. We contacted operations and maintenance technicians at 7 of the 20 Air Force sites that have an operational NEXRAD, and found that none of the technicians were aware of the tri-agency availability requirement. We then examined the availability data for these seven sites, and found that six of the seven were not meeting the requirement 13 to 44 percent of the time. Although the seventh site's data show it to be meeting the requirement, these data show 8 consecutive months of 100-percent availability, and thus as discussed earlier, are clearly unreliable and appear to be overstated.

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## Air Force Process for Obtaining Spares Is Inefficient, but Improvements Are Underway

The supply and logistics process that Air Force sites follow to obtain NEXRAD spare parts is inefficient and more time-consuming than NWS' process. Specifically, when an NWS radar needs a replacement part that is not on hand, technicians request the part directly from NWS' National Logistics Supply Center in Kansas City, Missouri. The Center, in turn, sends the part directly to the requesting site. In contrast, Air Force technicians must request the part from the Air Force's Sacramento Air Logistics Center, which records the transaction and electronically passes

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<sup>2</sup>Command, Control, Communications, and Computer Data Reporting Problem Process Action Team Summary Report, October 1994.

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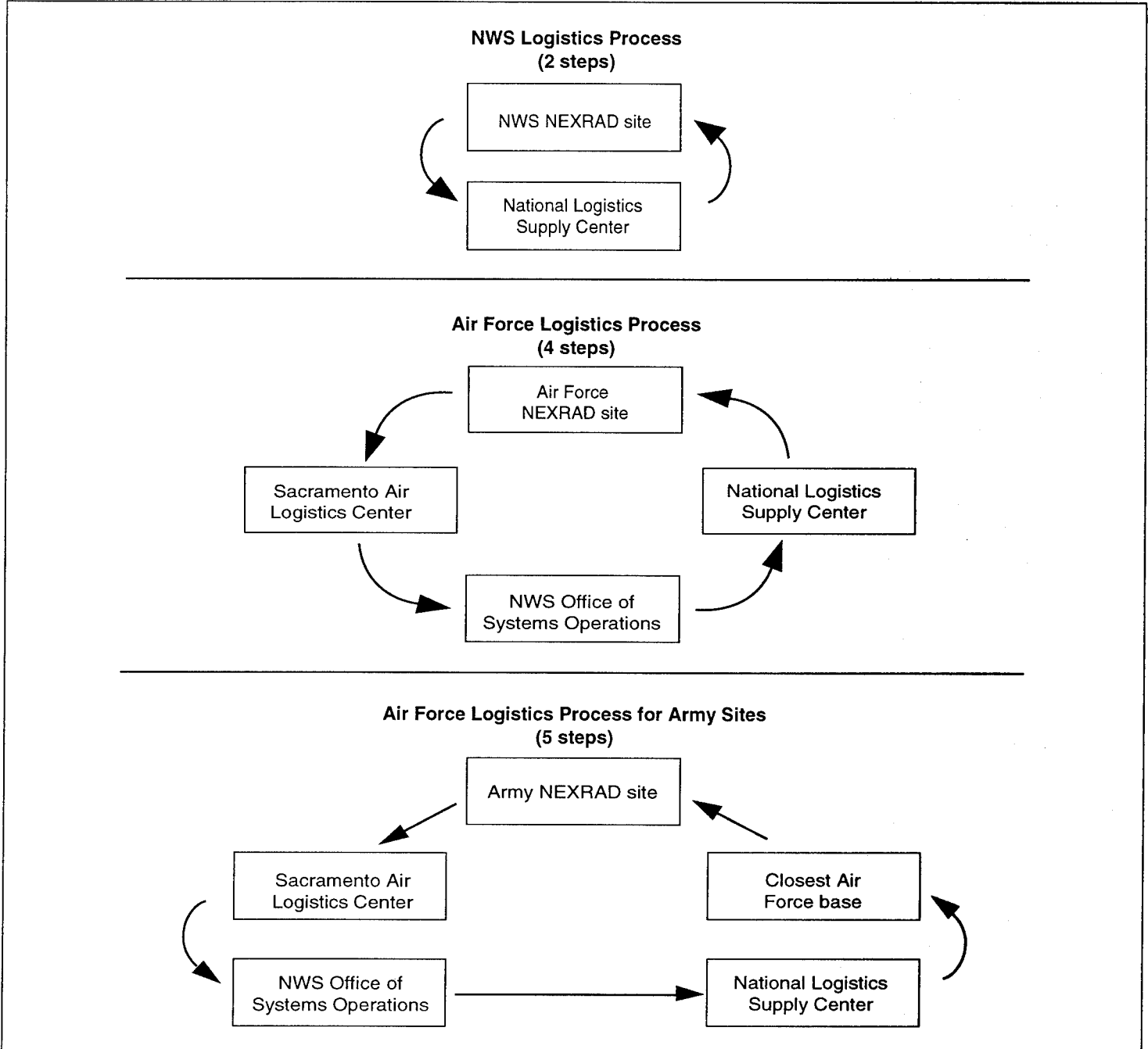
the request on to NWS' Office of Systems Operations for processing.<sup>3</sup> At this point the order is then processed in the same manner as an NWS order.

This problem is even more severe for the four CONUS Air Force NEXRADs located near Army installations, where parts that are ordered are first sent to the nearest Air Force base, which records the transaction and then ships the parts to the Army base. The distance between the Air Force and Army locations varies from 90 to 330 miles, causing an additional delay of at least 4 to 12 hours. Air Force officials told us that they strive to keep their NEXRADs operational 100 percent of the time; however, the current system component failure rates and the logistics process Air Force NEXRAD sites must follow to obtain spare parts from NWS' National Logistics Supply Center make it difficult to achieve the 96-percent availability requirement. Figure 5.2 shows the additional steps required for the Air Force and Army NEXRAD sites to obtain needed spare parts.

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<sup>3</sup>The requisitioning process through the Sacramento Air Logistics Center is required for financial tracking purposes.

Figure 5.2: NWS and Air Force NEXRAD Logistics Processes



NWS' Chief Logistician also identified several other logistics inefficiencies that contributed to the limited availability of the Air Force's NEXRADs. For example, until October 1994, the Air Logistics Center did not operate on evenings, nights, and weekends. Also, NWS did not have accurate and complete addresses for all Air Force NEXRAD sites, and thus parts would sometimes arrive at the base, but would not be delivered to the proper maintenance location. NWS' Chief Logistician stated that these problems have added days to the parts delivery process. Also contributing to the Air Force radars' availability shortfalls, according to the Chief Logistician, has been a limited supply of parts at Air Force NEXRAD sites.

To address these logistics concerns, NWS and Air Force officials established a logistics working group in September 1993. Members of this group stated that a number of the procedural problems have been eliminated. For example, they said that the group has automated the parts request process through the Air Logistics Center to the Office of Systems Operations so that parts orders can be placed 24 hours a day for emergency requisitions. They also said that the group provided NWS with complete addresses for all base supply organizations servicing Air Force NEXRAD sites. Also, they said that steps are underway to improve the stocking of on-site spares. In addition to these initiatives, they cited steps underway to provide better service to remote Army NEXRAD sites. For example, the Air Force is examining whether a common carrier can deliver parts to Army NEXRAD sites more quickly.

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## NWS Does Not Monitor Availability Data by Site

NWS does not calculate operational availability for each NEXRAD site, and thus does not know whether each radar site is meeting the availability requirement. Although NWS records radar downtime by site, it only uses this information to calculate the average availability of all sites, and it only monitors radar availability performance on this basis. It does not use this information to calculate and monitor site-specific availability. NWS officials stated that monitoring overall availability, rather than individual availability, is useful in determining such things as spare parts usage and maintenance staffing trends.

While we agree that such data on availability are useful, aggregate data do not allow NWS to determine whether each radar meets the required 96-percent availability requirement. The Office of Systems Operations Director agreed that it was important to track availability by site, and said that NWS would monitor availability on a site-by-site basis in the future.



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However, this change has yet to occur, and a time frame for doing so has not been established.

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## Conclusions

Air Force NEXRADs fall short of system availability requirements, thus increasing the risk that NWS will not have the data it needs to accurately and quickly predict severe weather. This risk is more severe than the data show because the Air Force availability data are unreliable and because NWS is not even analyzing and monitoring each radar's availability. While we believe that the steps described by Air Force and NWS officials to improve NEXRAD availability are reasonable, we did not verify that they have occurred. Further, the actual impact that each will have on system availability still remains to be seen, and the availability of NWS' sites also remains unknown. Until NWS and the Air Force meet stated radar availability requirements, lives and property are at greater risk.

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## Recommendations

We recommend that the Secretary of the Air Force direct the Air Force Director of Weather to improve the reliability of the Air Force NEXRAD availability data and to correct any shortfalls that these data show.

We recommend that the Secretary of Commerce direct the NOAA Assistant Administrator for Weather Services to begin analyzing and monitoring system availability data on a site-specific basis for its operational NEXRADs and correct any shortfalls in system availability that this analysis shows.

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## Agency Comments and Our Evaluation

In its comments, the Department of Defense concurred with our recommendation concerning the Air Force and stated that it will develop management actions by mid-fiscal year 1996 to improve NEXRAD availability and the reliability of DOD data.

The Department of Commerce also concurred with our recommendation concerning the analysis and monitoring of system availability data on a site-specific basis and stated that NWS is taking steps to allowing it to analyze and monitor system availability on a site-specific basis.



# Comments From the Department of Commerce



THE SECRETARY OF COMMERCE  
Washington, D.C. 20230

MAY -2 1995

The Honorable Gene L. Dodaro  
Assistant Comptroller General  
of the United States  
General Accounting Office  
Accounting and Information  
Management Division  
Washington, D.C. 20548

Dear Mr. Dodaro:

Enclosed is a copy of the Department of Commerce's reply to the General Accounting Office draft report entitled Weather Forecasting: Radar Availability Requirement Not Being Met.

These comments are prepared in accordance with the Office of Management and Budget Circular A-50.

Sincerely,

A handwritten signature in black ink, appearing to read "Ronald H. Brown", is written over the typed name.

Ronald H. Brown

Enclosure

RECOMMENDATION 1:

Assess the operational impact of FAA's delay in deploying the five radars, and on the basis of this assessment, take the necessary steps to ensure that National Weather Service's (NWS) radar coverage needs are met.

RESPONSE:

We concur with the recommendation but with comments. NWS does not have a mission requirement for radar coverage off-CONUS. However, data from planned FAA WSR-88Ds in Alaska, Hawaii, and the Caribbean will be used by the NWS, and given our experience with the radars to date, will greatly enhance NWS's ability to provide warnings and forecasts. A more accurate reflection of NWS's position can be found in the statement by the NOAA Assistant Administrator for Weather Services (page 35, 1st sentence of the 2nd paragraph) which states: "two of these radars in the Caribbean would allow NWS to better track and monitor hurricanes approaching the United states."

RECOMMENDATION 2:

Ensure that any radars bought in response to NRC's national radar coverage findings are cost beneficial, given that their unit cost may be three times higher under the terms of the existing contract option.

RESPONSE:

We partially concur with this recommendation. We concur that the requirements to procure additional radars must be justified. Any additional radars would be linked to the independent scientific NRC assessment, commissioned by the Administration and Congress, of proposed NEXRAD radar coverage and consolidation of field offices. More importantly, additional WSR-88Ds required as a result of the NRC study, if any, would be necessitated by NWS's core mission requirement: the protection of life and property, and Weather Service Modernization Act. NWS requests that this recommendation be modified to reflect only the core mission and Modernization Act requirements.

RECOMMENDATION 3:

Analyze and monitor system availability data on a site-specific basis for operational NEXRADs and correct any shortfalls in system availability that this analysis shows.

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Appendix I  
Comments From the Department of  
Commerce

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RESPONSE:

We concur with this recommendation. A new engineering management reporting system (EMRS) was implemented on October 1, 1994. Data are currently being collected via the EMRS that will allow the NWS to determine site-specific performance and reliability statistics. In the future, these data will be used to determine site-specific operational availability and to correct any shortfalls.

**General Comments:**

The draft report mentions the study by the National Academy of Science's National Research Council (NRC) several times. The NRC study is described in such a way that the reader could be left with the impression that there definitely are deficiencies in the modernized radar coverage, and that the purpose of the NRC study is to identify where these deficiencies are and recommend the number and location of additional WSR-88Ds needed to fill these gaps. This is not an accurate characterization of the NRC study. The assessment is of proposed NEXRAD radar coverage and consolidation of field offices in terms of the "no degradation of service" requirement of the Weather Service Modernization Act.

There are also several statements in the draft report attributed to NOAA to the effect that the number of WSR-88Ds currently planned are definitely sufficient to ensure no degradation in radar coverage at an elevation of 10,000 feet. The reader could conclude from these statements that NOAA has already determined that there are no gaps in modernized radar coverage. This would be an incorrect conclusion. A more accurate statement is that NOAA believes that the currently planned WSR-88D network will provide radar coverage equal to or better than the existing service. However, due to concerns raised by Congress and communities, the Secretary of Commerce established the independent examination by the NRC.

We agree that the Department of Defense (DOD) WSR-88Ds are essential to NWS's ability to issue quality forecasts and warnings. However, while the GAO Draft Report adequately describes most of the meteorological aspects of this need, it does not address the needs of the River Forecast Centers (RFC). The RFCs have access to the Hourly Digital Product (HDP) from a selected subset of DOD sites, but we believe the information is needed from all DOD radars. In addition, the DOD radars have not been configured to accept input from real-time rain gages as all NWS radars are. The DOD radars should have access to the rain gage data in order to compute the bias correction as all NWS radars do.

The draft document makes frequent reference to a change in the number of systems to be purchased and deployed under the contract with Unisys. The number still stands at 175. As a result of DOD base closures, the equipment required to create remote site configurations with redundant hardware in order to reduce maintenance return times, the added requirement for test and development platforms, and the need to shore up the logistical pipeline, the original location and disposition of 16 of the final system assets have been revised as illustrated in the attachment (Disposition of the 16 Production Systems).

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**Appendix I**  
**Comments From the Department of**  
**Commerce**

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Note: The Department of Commerce also included in its comments a statement that the existing contract option is an available vehicle for buying additional radars, and, thus, any references to the estimated costs of exercising this option are potentially acquisition sensitive. We have deleted this statement from the Department's comments because it identified the estimated unit cost.

# Comments From the Department of Defense



OFFICE OF THE DIRECTOR OF  
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3040 DEFENSE PENTAGON  
WASHINGTON, D.C. 20301-3040



MAY 11 1995

Mr. Gene L. Dodaro  
Assistant Comptroller General  
Accounting and Information Management Division  
U.S. General Accounting Office  
Washington, DC 20548

Dear Mr. Dodaro:

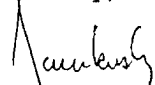
This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "WEATHER FORECASTING: Radar Availability Requirement Not Being Met" dated April 21, 1995 (GAO Code 511386, OSD Case 9914). The Department of Defense partially concurs with the report.

The DoD has reviewed the draft GAO report and concurs with the recommendation concerning DoD. The DoD, in consonance with the Next Generation Weather Radar (NEXRAD) Triagency partners, will develop management actions by mid-Fiscal Year 1996 to improve NEXRAD availability and the reliability of DoD data.

However, the draft report reflects confusion over the role DoD radars play in the National Weather Radar Network which is operated by the National Weather Service (NWS). The use of the term "backup", when associated with DoD NEXRAD sites, implies that the DoD sites located in the continental United States are integral parts of the national network. The term "backup" is not defined in either Federal Meteorological Handbook No. 11 (FMH-11), "Doppler Meteorological Observations", or the Memorandum of Agreement on Triagency Operation of the WSR-88D (i.e. NEXRAD). The FMH-11 defines a "network site" as a Department of Commerce WSR-88D in the continental United States, and "supplemental site" as a DoD site in the continental United States. Therefore, the term "supplemental" when referring to DoD NEXRAD sites has a specific, agreed upon meaning. To be correct and to prevent misinterpretation of the report, the term "supplemental" should be used throughout the report instead of the term "backup".

Technical corrections to the draft report were provided separately to the GAO staff. The Department appreciates the opportunity to comment on the draft report.

Sincerely,

  
John M. Bachkosky  
Deputy Director





# Major Contributors to This Report

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